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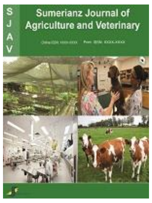

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Field Assessment of Strip-Tillage for Summer Rice Cultivation in Bangladesh

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Abstract

Farmers in the tropics and subtropics of Asia usually transplant rice seedlings in puddled soils which makes crop establishment and weed control easier. But rice can be grown successfully by planting into non-puddled soils after a single shallow pass of strip tillage. This method was globally reported to produce the same yield of rice as traditional puddle farming and saved labor, fuel and water, too. With this aim to asses the effect of strip tillage in the productivity of rice in Bangladesh, a trial was done at a farmer's field in the Gauriopur area of Mymensingh district in Bangladesh from July to December 2014. The productivity of four summer rice varieties, BR11, BRRI dhan46, BRRI dhan52, and BINA Dhan-7, was compared under strip tillage (ST) vs. conventional tillage (CT). The CT had two main ploughings done by a two-wheel tractor, and the ST was done in a single pass by a Versatile Multi-crop Planter. The interactive results of study showed that, except for the number of effective tillers per m^2, grain yield, and BCR, none of the other parameters changed significantly between the treatments. The highest BCR profit came from BR 11 grown under ST, followed by BRRI dhan52, BRRI dhan46, and BINA Dhan-7 grown under ST. The lowest BCR was measured from BINA Dhan-7 grown under CT. This could be because the highest and lowest amount of effective and sterile tillers and the maximum grain yield were seen in the respective treatments. The ST had a 26% higher BCR than the CT, which could have been due to the 3% higher grain yield that came from having 6% more effective tillers and 42% lower sterile tillers per m^2 area. In the end, we could say that ST is a more profitable way to grow rice than CT, and BR 11 is the best of the other three types.

Keywords: Conventional tillage; Profitability; Strip tillage; Variety; Yield.

1. Introduction

Rice cultivation in Bangladesh has used the traditional method of tillage, which involves puddling the soil and pouring water into the field to it, for an array of years. The next step is to harrow the paddy, shatter it, level it, and pull it. In recent years, this method of tillage, which is operated by a two- or four-wheel tractor or power tiller, has been plagued by a number of issues, including high costs, fuel and labour requirements, excessive water consumption, a lengthy cycle in ploughing and soil preparation, a limited quantity of straw returned to the field, poor soil health, and other issues. In addition, this practise has contributed to the deterioration of the natural health of the environment [1, 2].

Although puddling of soil helps to control weeds by uprooting, burying and killing them and facilitate easy transplanting of seedlings [3], rice cultivation through soil puddling should preferably be avoided due to its' detrimental effect on soil and climate, as well as an unfavorable practice for the succeeding upland crops [4]. Minimum tillage shows an advantage over puddling for maintaining physical condition and saving field preparation time and similar rice yield to that under conventional puddling with minimised expenses on field preparation [5]. Several minimum soil disturbing options could establish crops, and the strip-tillage (ST) is one of them which involves 15–25 % disturbance of soil surface with a slot up to 6 cm deep and 4–6 cm wide [6]. Recently, farmers are showing interest in growing crops with ST because it reduces cultivation cost, protects soil degradation, and saves and labor and water without yield sacrifice. Considerable research work has been done on puddle transplanting, but there is very limited data available on ST-based rice transplanting. It is important to evaluate the effect of ST on yield of different rice varieties. To consider this matter, the present on-farm study was conducted to examine the performance of four summer rice varieties under strip tillage system considering the growth and yield in Mymensingh region of Bangladesh.

2. Materials and Methods

2.1. Experimental site and Season

The on farm experiment was conducted at the Durbachara village of Vangnamari Union under Gouripur Upazilla in Mymensingh, Bangladesh during the period from July to December, 2014.

2.2. Edaphic and Climatice Condition

The land type was medium high with silty loam in texture with pH value 6.5, low in organic matter and fertility level. The climate of the locality is tropical in nature and is characterized by high temperature and heavy rainfall during April - September and scanty of rainfall associated with moderately low temperature during October – March. During the study period (July – December, 2014), July was the warmest month having the highest maximum and minimum temperatures were 33.5 and 26.7 ℃, respectively. December was the coldest month. The highest rainfall event comprising about 338 mm was recorded in July followed by August. November and December received no rainfall events.

2.3. Test Materials

Four rice varieties (cv. BINAdhan-7, BR11, BRRI dhan46, and BRRI dhan52) were used as the planting material under conventional vs. strip tillage arranged in randomized complete block design (RCBD) with four replications. Total numbers of unit plots were 2×4×4=32 and each plot size was 4.0 m × 2.5 m. Field layout was made according to experimental requirement. Good quality seeds of test materials were collected from the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. A piece of high land was selected for raising seedlings. The land was irrigated in the month of July and then puddled with two-wheel tractor (2 WT) for four times, cleaned and leveled with ladder. Then the sprouted seeds were sown in the nursery bed on June 30. Care was taken to see that there was no damage by birds and no infestation of pest, diseases and weeds were removed and irrigation was given in the seedling nursery as and when necessary.

2.4. Planting Operation

Land was prepared according to their treatments. Conventional tillage (CT) consisted of two passes primary tillage by 2 WT and exposed to sun for two days followed by inundating wholeplot and puddling by 2WT again with two passes to complete land preparation. The strip tillage (ST) was done by a Versatile Multi-crop Planter (VMP) in a single pass operation. Each strip had four rows, each 6 cm wide and 5 cm deep. Row distance was adjusted at 25 cm with 15 cm hill to hill distance. Three days before ST operation, glyphosate was applied @ 3.7 L ha^{-1}. After ST, the land was flooded with 3-5 cm standing water one day before transplanting to allow the strips to soften enough for transplanting seedlings.

2.5. Cultural Operation

The experimental plots were fertilized with urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate @ 210, 105, 75, 60 and 10 kg ha^{-1}, respectively. All the fertilizers expect urea were applied at the time of final land preparation. Top dressing of urea was done three times at 15, 30 and 45 days after transplanting (DAT) of rice seedlings. Twenty five days old seedlings were transplanted on plots. Three seedlings were transplanted in each hill maintaining a spacing of 25 cm × 15 cm. Intercultural operations like gap filling, weed control, irrigation and drainage were done for ensuring the normal growth of the crop.

2.6. Measurements

The crop was harvested at maturity on different dates as per maturity of different varieties of rice. Performance of rice varieties was assessed based on the plant characters and yield components from ten hills that were collected from each plot *viz.*, plant height, number of hills m^{-2}, number of effective and sterile tillers m^{-2}, panicle length, grains and sterile spikelets $panicle^{-1}$, weight of 1000-grains, grain yield and benefit cost ratio (BCR).

2.7. Data Analysis

Data were subjected to analysis of variance where; treatment means were separated by the Duncans' Multiple Range Test at $p<0.05$. The statistical package program *STAR* was used to analyze research data.

3. Results

3.1. Effects of Variety on Yield Attributes and Yield of Summer Rice

Variety exerted significant effect on plant height, the number of total tillers m^{-2}, number of productive tillers m^{-2}, number of sterile grains $panicle^{-1}$, grain yield, straw yield, biological yield and benefit cost ratio (Table 1). The tallest plant was recorded from BRRI dhan46 which was identical with BRRI dhan52. The medium height was recorded from BR 11 and the shortest plant was recorded from BINA Dhan-7. The highest number of productive tillers m^{-2} was recorded from BR11 followed by BRRI dhan46 and BRRI dhan52, and the lowest number of productive tillers m^{-2} was recorded from BINA Dhan-7. On the other hand, the highest number of sterile spikeles $panicle^{-1}$ was recorded from BRRI dhan52 followed by BR11 and BRRI dhan46 and the lowest number of sterile spikeles $panicle^{-1}$ was recorded from BINA Dhan-7.The highest grain yield was recorded from BR11 followed by BINA Dhan-7 and BRRI dhan52. The lowest grain yield was recorded from BRRI dhan46. The highest benefit cost ratiowas recorded from BR11 followed by BINA Dhan-7 and the lowest benefit cost ratio was recorded from BRRI dhan52 which was identical with BRRI dhan46.

Table-1. Effects of variety on yield attributes and yield of summer rice

Variety	Plant height (cm)	Hills m^{-2} (no.)	Productive tillers m^{-2} (no.)	Sterile tillers m^{-2} (no.)	Panicle length (cm)	Grains $panicle^{-1}$ (no.)	Sterile spikelets $panicle^{-1}$ (no.)	1000 - grains weight (g)	Grain yield (t ha^{-1})	BCR
BINA Dhan-7	93.09c	23	384d	95a	22.5	105	9.8d	24.2	5.15b	1.65b
BR11	106.54b	26	550a	53b	24.3	107	31.7b	24.4	5.47a	1.88a
BRRI dhan46	115.33a	22	522b	38c	26.8	98	20.3c	23.3	4.68d	1.54bc
BRRI dhan52	111.25ab	22	497c	47b	24.8	113	41.6a	25.9	4.97c	1.50c
$LSD_{(0.05)}$	4.88	1.79	8.83	6.02	3.97	16.4	7.28	2.78	0.10	0.12
CV (%)	4.41	7.52	3.74	9.92	5.51	15.0	12.26	11.02	1.98	4.72

CV = Co-efficient of variance, LSD= Least Significant Difference, CV= Co-efficient of Variance, BCR= Benefit-Cost Ratio. In a column, figures with the same letter or without letter do not differ significantly at P< 0.05.

3.2. Effect of Tillage on Yield Attributes and Yield of Summer Rice

Tillage exerted significant effect on the number of productive and sterile tillers m^{-2}, grain yield and benefit cost ratio (Table 2). The ST produced 2% higher number of effective tillers and 10% less number of sterile tillers m^{-2} than ST. Consequently, 4% higher grain yield was recorded from ST than CT. The higher benefit cost ratio and was 46% was recorded from ST than CT.

Table-2. Effects of tillage practice on yield attributes and yield of summer rice

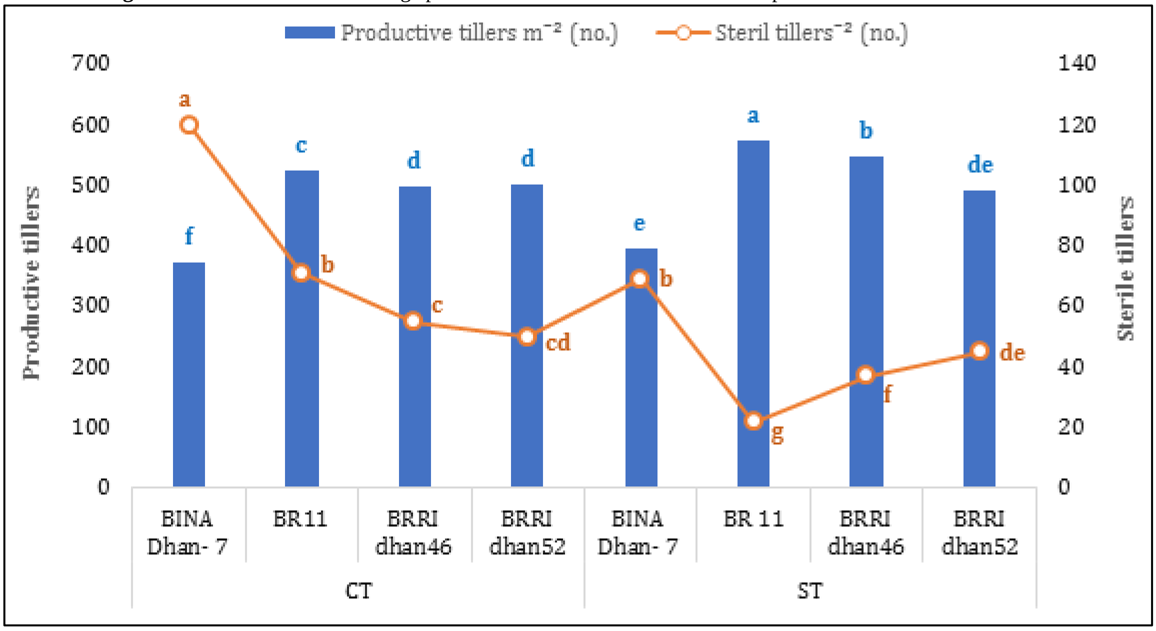
Tillage	Plant height (cm)	Hills m^{-2} (no.)	Productive tillers m^{-2} (no.)	Sterile tillers m^{-2} (no.)	Panicle length (cm)	Grains $panicle^{-1}$ (no.)	Sterile spikelets $panicle^{-1}$ (no.)	1000-grains weight (g)	Grain yield (t ha^{-1})	BCR
CT	106.8	23	503b	61a	24.1	105	24	24.4	5.05b	1.34b
ST	107.3	23	511a	55b	25.2	106	27	24.6	5.23a	1.95a
$LSD_{0.05}$	3.45	1.27	6.24	4.25	2.81	11.6	5.15	1.96	0.07	0.37
CV(%)	4.41	7.52	3.74	9.92	5.51	15.0	12.26	11.02	1.98	4.72

CV = Co-efficient of variance, LSD= Least Significant Difference, CV= Co-efficient of Variance, BCR= Benefit-Cost Ratio. In a column, figures with the same letter or without letter do not differ significantly at P< 0.05.

3.3. Interaction Effect of Variety and Tillage on Yield Attributes and Yield of Summer Rice

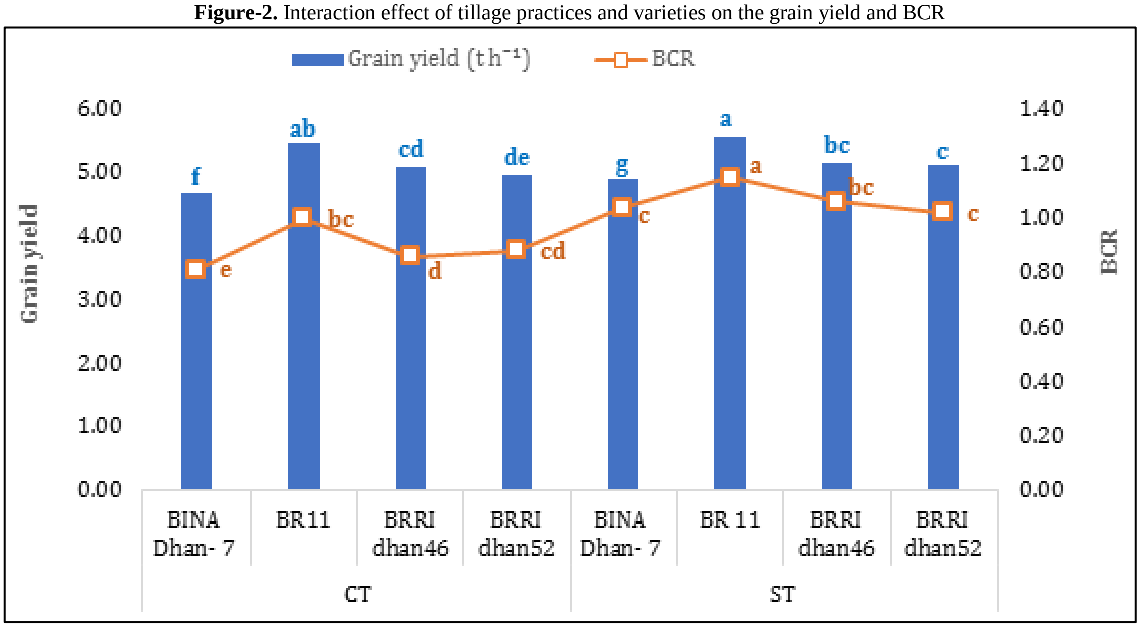
Interaction effect of varieties and tillage types on the number of productive and sterile tillers m^{-2}, grain yield and benefit cost ratio were significant ($P<0.05$). The highest and lowest number of effective and sterile tillers m^{-2}, respectively was recorded from BR 11 under ST system followed by BRRI dhan46, BRRI dhan52 and BINA Dhan-7 under ST. On the other hand, the lowest and highest number of productive and sterile tillers m^{-2} was recorded from BINA Dhan-7 under CT followed by BR11, BRRI dhan46 and BRRI dhan52 under CT (Figure 1).

Figure-1. Interaction effect of tillage practices and varieties on the number of productive and sterile tillers m-2



Variety BR11 produced the highest grain yield under ST followed by this variety under CT. While the lowest grain yield was recorded from BINA Dhan-7 under CT (Figure 2). BRRI dhan52 and BRRI dhan 46 ranked the thrd and fourth posion in ST followed by CT. The highest BCR was recorded from BR11 under ST followed by BRRI dhan46 and BRRI dhan 52 under ST and CT, respectively. While the lowest BCR was recorded from BINA Dhan-7 under CT followed by this variety under ST (Figure 2).

Figure-2. Interaction effect of tillage practices and varieties on the grain yield and BCR



4. Discussion

In this study four rice vaierties and two tillage types exerterted significant effect on the variation of plant characters, yield and BCR. Plant height is an important agronomic characteristic considered in rice evaluation trials. Rice breeders and physiologists consider plant height as one of the most important criteria. Differences in plant height of the varieties were mainly due to varietal variation [7]. This variation in plant height was probably due to the genetically make-up of the genotypes. Plant height is more important from the viewpoint of farmers' preference for variety adoption [8]. Since farmers use rice straw as cattle feed, the farmers prefer those varieties which gives higher yield as well as more straw. In this study, plant height was varied by the tillage types that confirms the adoption probability of ST by the farmers.

In this study, BR11 variety uproduced the highest number of productive tillers hill-1. This might be attributed to varietal ability of produced the panicle bearing tillers. Number of productive tillers hill^{-1} is an important yield component of rice crop which has direct relation with the grain yield. Yoshida [9], mentioned that number of panicles bearing heads in rice is determined by the tillering ability of a variety. Number of panicles bearing tillers is regarded as one of the most important yield components in rice which determine the ultimate yield [10]. According the to Hossain, *et al.* [11] in lined with Ndebe, *et al.* [12] and Rahman, *et al.* [13], reported that rice varieties have the genetic potential to generate more efficient tillers per hill and a greater number of robust grains per panicle, which are thought to contribute to the increased grain production of rice. These varietal differences might led to the variation of productive tillars in this study, that is in line with Islam, *et al.* [14] also.

Differences in the number of grains panicle^{-1} is mainly due to morphological and varietal variation and have influenced the differences among all the varietise in the present study. The previous reports indicate that the longer panicle has the capability of producing the greater number of effective tillers and a greater number of grains [9, 15, 16]. Besides, the variation of solar radiation (sunshine hours) also has impact on translocation of photosynthates from the source to sink that might have influenced the variation of the number of grains the test materials in this study. The genotypes, which produced higher number of productive tillers hill^{-1} and higher number of grains per panicle with the robust grains [17]. The higher number of productive tillers and grains panicle^{-1} led to produce the lower number of non-porductive tillers and sterile spikelets, respectively also attributed the variation in grain yield among rice varieties [18] that ultimately caused to vary the BCR in this study.

The higher yield in ST of present study agrees might be attributed to the higher number of of productive tillers and the lower number of non-productive tillers in this study. This findings agrees the research findings of Hossain, *et al.* [19] who found the higher rice yield in ST than CT, due the beneficial effect of ST on grain yield could be attributed to that change in soil properties. The higher total porosity and better soil moisture conservation favoured the root growth and nutrient uptake resulted in increase in grain yield in ST [20]. The ST provide more favourable soil physical environment for crop growth than CT [21]. It was also reported that the higher and more stable crop yields in ST than CT occurred from the formation of surface crust by heavy pulverization of the surface soil [22], leading to loss of structure and homogenization of the cultivated layer, which resulting in discontinuity of the conducting pores and compaction of the soil below the cultivated layer due to the pressure from the tractor wheels in CT.

In addition to that, Zheng, *et al.* [23] found crop yield increase in ST may through improving soil fertility by conserving soil and water and sequestering organic carbon in farmland soils that reduces the extremes of water logging and drought. Alam, *et al.* [24], concluded, yield increase in MT might be associated with the improvement of soil structure and stability thereby facilitating better drainage and water holding capacity. Higher infiltration rates and propitious moisture dynamics supported up to 30% yield increase in maize under ST [25] due to increase of soil organic carbon, soil total nitrogen and soil total phosphorus by 25, 18 and 7%, respectively in the ST than CT [26]. These findings have implications for understanding the impact ST to increase the yield of rice by improving soil quality and sustainability.

Variation in BCR might be attributed to the variation in grain yield and cost required for cultivation in CT and ST. Savings in the ST over CT might have attributed to the savings from tillage operations weeding costs and labor requirements by 67%, 58% and 22%, respectively, in this study (data not shown). The variation of BCR in different varieties unde the same tillage might be due to the variation of selling price of rice due to their physical and chemical properties that influences the variation the preferences of customers.

5. Conclusion

In light of the above, it is reasonable to infer that, of the four tested rice varieties, BR11 fared best when grown using a strip tillage technique, and that using such a system to grow BR11 yielded the most financial benefit to the farmer. In order to corroborate the conclusions of the study, however, further research is required.

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